PROJECT IDEA SUBMISSION – *STUDENT*

Team Contacts

- 1st person listed serves as the point of contact with Professor Jensen
- Initial team size may be from 4 to 6 members (all members must agree to have their name included)

NAME	PHONE	EMAIL
David Krouse	972-415-5815	kroused@purdue.edu
Davin Landry	832-712-9179	dlandry@purdue.edu
Josh Walker	901-619-4075	walke333@purdue.edu
Mariko Siewenie	224-688-2684	msieweni@purdue.edu

Note: Course policy prohibits projects involving weapons, or significant safety risk.

PROJECT NAME

Automatic CVT for Constant Torque Input on a Bicycle (Bicycle CVT)

PROJECT DESCRIPTION

This project will involve creating a replacement for the standard cassette and shifting system mounted on the rear wheel of a bicycle with a system that continuously and automatically shifts the mechanical advantage of the transmission based on the load such that the user may provide a constant input torque, improving the user's comfort over the duration of the ride and allowing the user to continuously use as much power as desired, to be set mechanically on the CVT before the ride begins.

WHAT IS THE PROBLEM YOU ARE TRYING TO SOLVE?

The problem being addressed for this project is the lack of efficiency, variability, and ease of use of current gear-shifting systems on bicycles. During everyday bicycle use, the gears are rarely used to their greatest potential. Bicycle chains also have a tendency to malfunction and skip or fall off track when switching gears, which can cause accidents.

The gear switch process can also be confusing and slow, making them less likely to be utilized while riding casually.

WHY IS IT A PROBLEM WORTH SOLVING?

When bikers are not using the most effective gear positioning on their bike, some of the energy that they exert is lost and/or becomes ineffective when driving the bike forward. With the solution we provide, power provided from the user will be more efficiently transferred at the most effective gear ratios, all without any additional input or triggers from the user, creating a better biking experience.

MARKET ANALYSIS: WHO ARE THE TARGET CUSTOMERS AND HOW WILL THEY BENEFIT FROM YOUR PROPOSED PRODUCT?

Initially, our target market will be manufacturers of high-end bicycles for wealthy hobbyists that spend large amounts of money on bicycles, because they are the driving force behind profit in the bicycle manufacturing industry that remains in the US. Many low-cost bicycles are driven out of business by the low prices of bicycles manufactured abroad, and profitability for companies is often based on their high-end products. Bicycle manufacturing is a 891 million dollar industry and is very segmented, with the top company holding 12.8% of the market share, and no other companies anywhere close. Starting with wealthy bicycle hobbyists, our product will allow riders to put the same force on their pedals throughout their rides, without having to adjust gears as the geography changes. However, eventually we want to make our technology affordable enough to sell to manufacturers as a technology for most of their bikes, high and low-end. Instead of having to produce bikes that use this technology specially, it could be incorporated into all bicycles.

BENCHMARK RESEARCH: WHAT SOLUTIONS EXIST TODAY AND HOW IS YOUR PROPOSED PRODUCT SOLVING THE PROBLEM UNIQUELY AND BETTER? DESCRIBE RELEVANT PATENTS AND COMMERCIAL PRODUCTS INCLUDING THEIR FUNCTIONAL PERFORMANCE AND COST.

There are several concepts for a CVT on a bike, however none of them are readily available on the market, with outdated websites and no easy way to obtain them. The BitRaptor IVT bicycle and LandRider autoshift bicycle are examples of ideas not fully expressed into the mainstream market. The BitRaptor does not have a cost associated with the product because it is not truly commercially available. An example of a used Auto-shift Landrider was found in a online resale store for $600, but only seems to be available through third party sellers like E-Bay and Amazon. Our solution would be an improvement over these designs and other prototypes because some prototypes weigh up

to 20 pounds and have complaints about battery charge time and jerky shifting. Our design will attempt to provide smooth

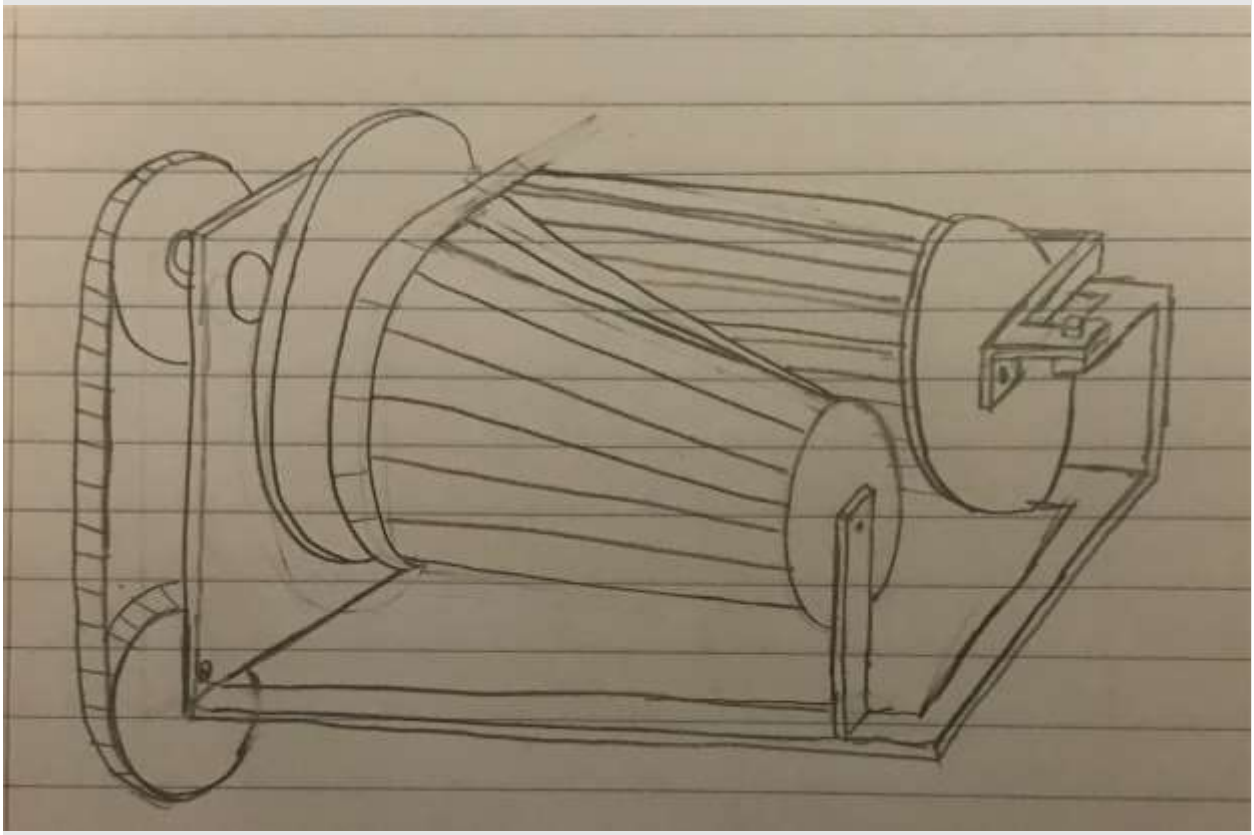
There are two patents relating to our product currently filed by the US patent office, US9005068B2 and US7803077B1. Respectively, these are the continuously variable bicycle transmission mechanism and bicycle hub, and the constant torque infinitely variable automatic transmission. We will have to work outside of these patents to design our device. However, since no commercial product has become popular from those patents, it should be possible to create a better alternative without infringing on patent law. The CVT patent outlines what constitutes a bicycle CVT; including a ring roller, conical planetary roller, sun roller and a carrier. The constant input torque patent also outlines the components that make up the infinitely variable transmission and how they work together.

DESIGN: DESCRIPTION OF YOUR PROPOSED SOLUTION(S). DESCRIBE THE FUNCTIONAL REQUIREMENTS FOR THE FINAL PRODUCT. INCLUDE PRELIMINARY SKETCHES OF THE INITIAL CONCEPT(S), AND EXPLAIN HOW THEY ARE INNOVATIVE.

The main functional requirement of our device is that it can function as a normal gear train for a bicycle, but in addition automatically shift to keep input torque constant for changing geography. It should be housed or somehow protected as not be affected by weather. The technology should be able to fit most bicycle sizes and types as to be relatively universal.

Our design is innovative because it takes something that was partially accomplished in cars and integrates it into bicycles. Biking can be very inefficient at times and our design hopes to remove that inefficiency by using constant torque continuously variable transmission with automatic shifting to take the pressure of shifting off the biker. Specifics of the design are discussed below in the Engineering section.

The figure below shows the basic design of what we are trying to accomplish, but there will be many iterations.



SYNTHESIS: WHAT ENGINEERING PRINCIPLES WILL BE USED ON THE PROJECT AND HOW?

Safety and Reliability: Bicycle riders often travel at high speeds with minimal protection. The device should be built with a high level of durability and redundancy to prevent catastrophic failure on the road.

Affordability/ Manufacturability: Bikes have been produced for a long time and the standard cassette can be produced efficiently and cheaply. In order to be competitive, the device must be relatively inexpensive to produce. Therefore, the device should be made of standard parts and common materials without having too many components.

Minimalism: A heavy product will weigh down the user and make travelling up hills needlessly difficult. The device should ease the user's burden, not increase it. Therefore, the device should be kept lightweight.

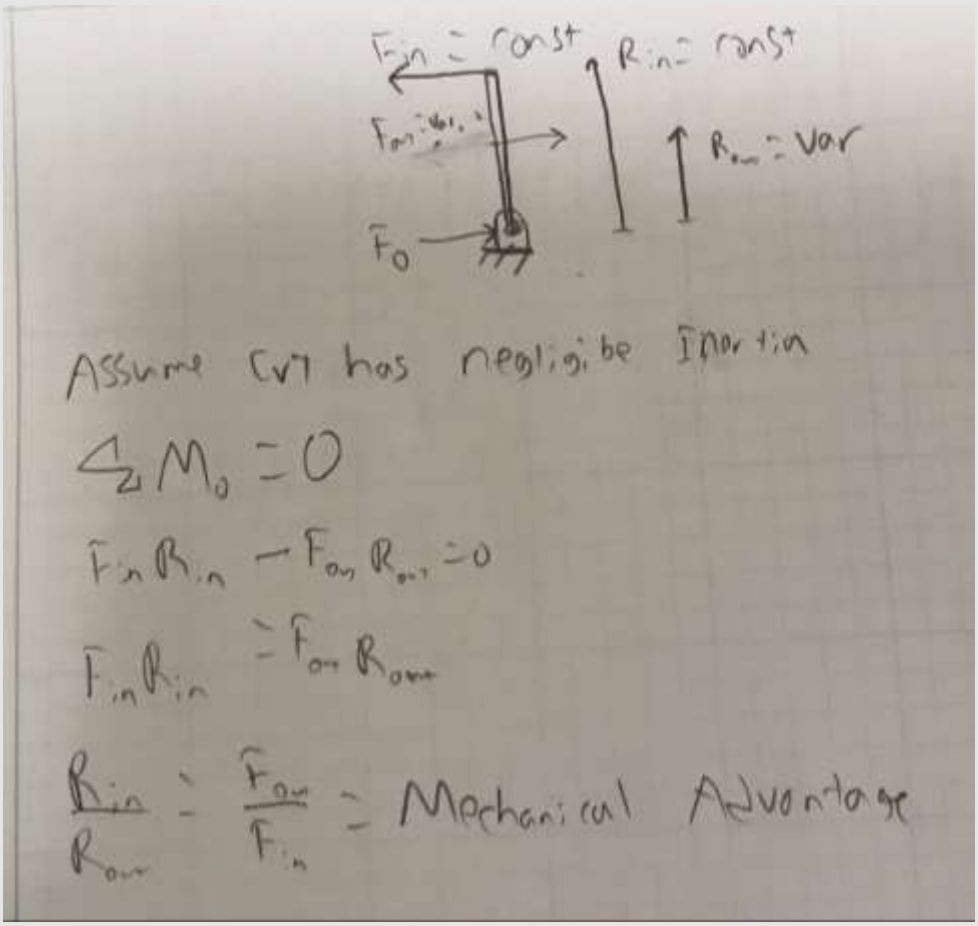
Usability: To maximize the market cap, the device should be interchangeable with other rear-wheel hubs. This will decrease the implementation cost to bicycle manufacturers and end users.

ENGINEERING: EXPLAIN THE PHYSICS/ENGINEERING ASSOCIATED WITH THE PROBLEM. (Include Free-body diagrams or other sketches as necessary)

The CVT must make use of an automatically responsive machine that varies its mechanical advantage in order to keep the required input torque close to a specified level. The physical phenomena used for this purpose is a power balance used to determine the optimal mechanical advantage for any given input speed. A small and practical controller must be designed such that it keeps the mechanical advantage within a specified tolerance of the optimal value, and a static analysis must be made of the system to ensure that all parts are never loaded beyond their yielding strength. In addition, a fatigue analysis must be done as a bicycle tire will rotate hundreds of times per mile, and a well-used bike can travel thousands or tens of thousands of miles.

The input of the CVT will be connected to the same standard crankshaft currently used on bicycles. During normal operation, the user will pedal at a constant velocity, transmitting power through the CVT and output to the wheel of the bike. There must be a limited maximum and minimum mechanical advantage to the CVT so that the user can start from rest, and so that the maximum speed can be limited to avoid damage. The user will make no conscious decision to accelerate to a given velocity, rather, the device will smoothly balance power between countering friction and providing additional kinetic energy. When the user desires to stop the device should allow the wheel to ratchet freely so the user may cease pedaling as the brakes are operated. While this occurs, the device should detect the decrease in speed and therefore return to providing a high mechanical advantage so that the user may begin to smoothly accelerate again.

The controller for the mechanical advantage of the CVT may take as input either the output speed or torque, or use a combination of the two. The mechanical advantage should be directly proportional to the torque and inversely proportional to the speed.



MANUFACTURING: EXPLAIN HOW THE PROTOTYPE WILL BE BUILT & TESTED.

The prototype CVT will be built using the manufacturing capabilities of the BIDC and the ME machine shop, with non-critical components being produced by a 3D printer. Manufacturing tolerances will be drafted in order to satisfy operating efficiency requirements and free rolling parts will be tested to ensure minimal damping occurs within the system. The device will be driven by an electric motor with constant power input and standard bicycle brakes will be affixed to the output such that various loads can be applied. The clamping force of the brakes will vary cyclically to control the output torque and the resulting output speed will be monitored to see if power output is constant as expected. In addition, the speed and torque of the motor will be tracked throughout the process to ensure they stay within the desired operating range. The device will be judged by the time response in changing the mechanical advantage with a varying output load and by the error between optimal mechanical advantage and the actual mechanical advantage.

IMPACT: HOW WILL THE SOLUTION CREATE BUSINESS AND/OR SOCIETY VALUE?

The solution will bring a completely different and new kind of bike within reach of the average consumer, opening the market of an affordable and modern style bike built for everyday performance and efficiency. This gear system would be an alternative option to current cassette gearing methods. By taking the gear switching hassle off of the user's shoulders, the new bike will be riding at the most efficient gear at all times during a ride.

Save the file with the following nomenclature: project name - point of contact full name.docx

Email completed form to Professor Jensen at jensen23@purdue.edu to request project approval.